INSTRUCTIONS 198 455-K10-001

PORTABLE INSTRUMENTS TYPES AP-9 AND DP-9

(THIS PUBLICATION FORMERLY IDENTIFIED AS GEJ-447)

AC 3/4 %
DC 1/2 %

GENERAL ELECTRIC

PORTABLE INSTRUMENTS

TYPE AP-9—ALTERNATING CURRENT
TYPE DP-9—DIRECT CURRENT

Reasonable care must be exercised when handling or transporting these instruments. If not carried by hand, pack them in the original cartons, or, if these are unavailable, pack in three or four inches of excelsior. If transportation is by automobile, place them on the cushions either topside down or on edge. In the first case, there is little likelihood of stickiness developing, because the jars are transmitted to the top pivot and jewel. In the second case, the stresses are carried by the sides of the two pivots, and usually there is little likelihood of injuring the delicate pivot ends.

Adjustment of Zero

All instruments with permanent zero markings on the scale are provided with an external zero adjustment screw. If the pointer should be off zero, when received from the factory, or if

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

during subsequent use it should be found slightly off, adjustment should be made carefully by a small screwdriver. If the departure from zero is due to pointer distortion as a result of severe overloading, the pointer should be carefully straightened by a competent instrument mechanic before an attempt is made to adjust zero, or the instrument should be returned to the factory. Balance and calibration should be checked after any mechanical adjustment, excepting movement of the zero setter.

Position

These instruments are designed for use in approximately level positions. Highly accurate leveling is, however, unnecessary. When necessary and when results of highest accuracy are not required, the instruments may be used at angles up to 45 degrees or even in the vertical position.

The Scale

The scales of portable instruments are divided and subdivided in a manner to facilitate quick, accurate readings. The mirror in the scale is to assist the operator in preventing parallax errors. When taking a reading, the eye should be directly over the pointer so that the reflection of the pointer in the mirror is completely covered by the pointer itself.

Scale Readings—Multi-range Instruments

The scales of multi-range instruments are

usually marked for **direct** reading on the lowest and one or more of the higher current or potential ranges. In some cases it is not practical to mark all scale ranges, and in these cases, the lowest scale should be used with a suitable multiplying constant. The multiplying constant is the ratio of the lowest current or voltage tap to the marking of the current or voltage tap in use. For example, consider a 150/300/600-volt voltmeter with 150- and 600-volt scales marked and used on 300 tap. If the reading is 112 volts, multiply by $\frac{300}{150}$ or 2 and obtain 224 volts.

Similarly, in wattmeters read the lowest scale and multiply by the ratio.

$$\frac{\text{current tap in use}}{\text{lowest current tap}} \times \frac{\text{voltage tap in use}}{\text{lowest voltage tap}}$$

EXAMPLE:

5/10-amp 150/300-volt wattmeter with .75/1.5 kilowatt scale marking and used on 10-amp 300-volt taps.

With a reading of 0.60 kilowatt, multiply by $\frac{10}{5} \times \frac{300}{150} = 4$, the Multiplying Constant

$4 \times 0.60 = 2.40$ kilowatts

These multiplying constants are always simple units and are usually 2 or 4.

Static Charges on Glass

When the glass window is rubbed to remove dirt, static electricity is generated that may interfere with the accuracy of an indication. This static electricity can be removed completely by breathing lightly upon the glass.

TYPE AP-9 INSTRUMENTS

Polarity

Type AP-9 voltmeters have one post marked ± and this should be connected to the grounded side of the line under test if the line is grounded. Each of the other binding posts is marked by engraved numbers on the case adjacent to the binding posts.

Type AP-9 ammeters have markings near the binding posts.

Type AP-9 wattmeters have a ± mark near one potential post and also near one current post. These two points should be connected to the same side of the line and therefore will be at substantially the same potential. In some testing it is necessary at times to reverse one connection. This should be the current connection. This prevents undue voltage differences between the armature and field coils.

Accuracy

Type AP-9 instruments of standard ratings have an initial accuracy of ¾ per cent of the full scale value. Voltmeters must be energized 20 minutes prior to taking readings requiring maximum accuracy. Compensated voltage survey

voltmeters Cat. No. 8AP9VAV and 8AP9VBH have an initial accuracy of ½ per cent of the full scale value over the upper ½ scale range measured in volts.

Continuous Use in Circuit

All instruments may be energized continuously within the limits marked on the scale plate.

Use on Direct Current

Type AP-9 single- and double-range ammeters, all voltmeters, and all wattmeters may be used on d-c circuits, for approximate measurement of currents, voltages, and power. When so used, avoid subjecting the instruments to severe overloads and, if conditions permit, take the mean of reversed readings as the true value of the observed quantity. These instruments are, however, intended primarily for a-c use. They are calibrated on a-c at the factory; any calibration checks should be made on a-c.

Three- and four-range ammeters have an internal transformer and cannot be used on d-c.

Ground Connections

Ground connections are recommended for **ungrounded** single-phase circuits of potentials ranging from 220 to 750 volts. The grounded side of the line, whether a part of the system itself or added for protection during measurement, should be connected to the ± post so that no resistors will be interposed between the terminals and ground. Current and potential transformers are recommended for circuits

above 750 volts. Their secondaries should be grounded. Suggested ground connections are shown in the wiring diagrams included in this book. These may be subject to modifications where local conditions so require.

A-C VOLTMETERS

Movement

The Type AP-9 voltmeter is an inclined-coil instrument having an iron vane armature and fixed field coil.

Connections

When using a multiple-range instrument to measure an unknown voltage the highest range should be tried first. If the indication is sufficiently low a lower scale may then be used.

Voltmeters are high-resistance instruments and should be connected across the line as shown in Fig. 2.

As shown in Fig. 2 the higher range of the voltmeter is used.

Extension of Ranges

It is possible to extend the range of voltmeters by the use of multipliers (external resistances). Unless these are Type YR multipliers built for use with these instruments, care should be exercised to see that they are non-inductive, of sufficient current capacity, well insulated for the circuit voltage to which they are to be connected, and wound of wire having a negligible resistance temperature coefficient.

When multipliers are used, the indications of the instrument should be multiplied by the following constant:

$$K = \frac{\text{Resis. of Instrument} + \text{Resis. of Multiplier}}{\text{Resistance of Instrument}}$$

The resistance of the multiplier is given on the nameplate. One binding post is marked "0." The other (or others, depending upon whether the multiplier has one or more ranges) is stamped with a constant. This constant is the multiplier ratio and is the number by which the instrument reading should be multiplied to obtain the true voltage.

For example, a 4:1 multiplier is connected to the 150-volt post of a 150/300-volt instrument. The corrected reading on the 150-volt scale is 142 volts. The true voltage then is: $4 \times 142 = 568$ volts.

When voltages of over 750 volts are to be measured the use of instrument potential transformers, rather than multipliers, is recommended.

A-C AMMETERS

Movement

The Type AP-9 ammeter is an inclined coil instrument having an iron vane armature and fixed field coil.

Connections

Since an ammeter is an instrument of very low resistance it should **never** be connected

across the load, but **always** in series with it. The following diagrams show methods of connecting:

The ammeter in Fig. 5 is of double range and is connected for use on the higher range. When connecting the ammeter into a circuit of unknown current value, the higher range should be used first. If the indication is too low upon the scale, connect to the lower range. Fig. 6 and 7 show alternative methods of connecting voltmeters and ammeters for measurement of volt-amperes.

In Fig. 6 the ammeter is connected between voltmeter and load. The load voltage is lower than the indicated value by the amount of the impedance drop in the ammeter. Using the 5-ampere scale at 5 amperes, the correction amounts to about 0.2 volt, and correction is usually unnecessary for currents of this magnitude.

In Fig. 7 the voltmeter is connected between ammeter and load. The load current is lower than the indicated value by the amount of current taken by the voltmeter. This is the preferred connection when the degree of precision requires corrections in the observed value. Compute the value of voltmeter current by dividing the observed voltage by the resistance given on the scale plate and subtract from the ammeter reading to obtain the correct load current.

Extension of Ranges

The range of ammeters may be extended by the use of instrument current transformers. Connections should be as shown in Fig. 8.

Current transformers are also suggested on circuits where conditions are hazardous as they can insulate effectively the instrument from high voltages.

Standard current transformers are built for a secondary current of 5 amperes, and may be used with any AP-9 instrument having a 5-ampere range. See "'Use of Ammeters with Current Transformers," page 16.

A-C SINGLE-PHASE WATTMETERS

Movement

The AP-9 wattmeter is an electrodynamic instrument. The moving element carries a coil excited by the potential. The field is produced by the current flowing through a fixed field coil.

External Connections

When using a multiple-range instrument to measure unknown power, the highest range should be tried first. If the indication is too low, a lower scale may then be used. It is advisable to protect wattmeters from overload by first trying the circuit with voltmeters and ammeters.

Fig. 9 to 19, inclusive, show the proper methods of connection.

As shown in Fig. 9, the wattmeter measures the power loss in its own current circuit plus the power in the load. An alternative scheme is shown in Fig. 10.

The "±" post of the potential circuit should always be connected to the same side of the line as the current leads. This is necessary to prevent electrostatic forces between the armature and surrounding parts.

If, on connecting, the instrument is found to be reversed (to indicate backwards) the **current** leads should be reversed to make the instrument indicate properly.

When connected as shown in Fig. 10 the wattmeter measures the loss in its potential circuit plus the power in the load. However, this potential loss can be subtracted out directly when the precision of the results warrants. The loss in the potential circuit can be computed from the scale data as

$$\text{Watt Loss} = \frac{E^2}{\text{Resistance of Potential Circuit}}$$

when "E" is the voltage of the line.

With the connections shown in Fig. 11, the voltage is that across the wattmeter current circuit plus the load, and the watts indicated by the wattmeter are also the power in the wattmeter current circuit and the load.

With the connection shown in Fig. 12, the voltage indicated is that directly across the

load. However, the wattmeter indication is the sum of the loss in the load plus the losses of the voltmeter and the potential circuit of the wattmeter. The indication can be corrected by subtracting these instrument losses out of the indication as pointed out in discussing the connections in Fig. 10.

Connection diagram, Fig. 13, is similar to Fig. 11. The same remarks apply to it. The wattmeter indicates the power load plus its own series loss plus the loss in the ammeter. For most purposes these latter are too small to consider. An alternative scheme is shown in Fig. 14.

With the connections shown in Fig. 14, the wattmeter indications are the sum of the power losses of the load, the potential circuit of the wattmeter, and the voltmeter. See Fig. 10 and 12. An easy correction can be applied for these instrument losses. The ammeter also indicates the sum of the load current plus the currents in the voltmeter and in the potential circuit of the wattmeter.

With the connections shown in Fig. 13 or 14, the power factor of the circuit can be determined. It is

$$\text{Power Factor} = \frac{\text{Watts}}{\text{Volts} \times \text{Amperes}}$$

"Watts" in this case is the wattmeter reading minus the loss in current or voltage circuits, depending on the method of connection.

For tests on polyphase power circuits, the connections shown in Fig. 15 to 17, inclusive, are used. These are shown only for the wattmeter, as it should be understood that ammeters and voltmeters can be connected into these circuits in accordance with the preceding diagrams.

For balanced 3-phase 4-wire circuits, the power of the system is three times the indication of the wattmeter (as shown in Fig. 15). The wattmeter indicates its own potential losses plus those of one phase of the load. This potential circuit loss can be corrected out (see Fig. 10 and 11) or the wattmeter can be connected as in Fig. 9 or 11.

In general, the two wattmeters connected as shown in Fig. 16 will not indicate alike, even if the load is balanced. The true power is the sum of the indications of the two wattmeters, at power factors of 0.5 or over. At 0.5 power factor one wattmeter indicates zero and the other the total power in the circuits. Below 0.5 power factor, one wattmeter will read backward. To make it read correctly, interchange the current leads. The small reading must then be subtracted from the larger. The **current** leads should be reversed so that the zero of the potential circuit will be at the same potential as the current coils in the instrument. This is necessary to prevent electrostatic forces on the armature.

Two wattmeters connected as in Fig. 17 are usually used for measuring 2-phase 3-wire,

balanced or unbalanced loads. The power is the sum of the indications of the wattmeters. If the load is known to be balanced, one wattmeter alone may be used and its indication multiplied by 2 to get the true power of the system.

Extension of Ranges

The ranges of wattmeters may be extended by the use of multipliers or instrument potential transformers in the the potential circuit and by the use of current transformers in the current circuit, or both. The precautions to be taken are similar to those necessary when using the same methods for extending the ranges by voltmeters and ammeters.

When multipliers are employed which are not Type YR multipliers built for use with these instruments they should be noninductive, of a sufficient current rating, and well insulated and wound of wire having a negligible resistance temperature coefficient. The connections should be made as in Fig. 18.

The constant by which the corrected reading should be multiplied to obtain the true watts may be obtained in the following manner:

$$K = \frac{\text{Resis. of Instrument} + \text{Resis. of Multiplier}}{\text{Resistance of Instrument}}$$

The use of potential and current transformers

is strongly urged on circuits of 750 volts and over, or where conditions are hazardous.

USE OF INSTRUMENTS WITH INSTRUMENT TRANSFORMERS

The direct measurement of high voltage or large currents would involve large, heavy, and expensive instruments in a wide variety of designs. Consequently instrument transformers are used as an insulating and transforming link so that these measurements may be made readily and safely with comparatively inexpensive instruments.

There are two distinct classes of instrument transformers: instrument potential transformers, and instrument current transformers. The word "instrument" is usually omitted for brevity.

Use of Ammeters with Current Transformers

A current transformer has two general uses: first, as a protective device in the measurement of current in a high-voltage line; second, to facilitate the measurement of large currents, which may or may not be in a high-voltage circuit.

Current transformers have at least two separate windings or circuits, known as the primary and secondary.

The primary winding is connected in series with the circuit in which the current is to be measured. The secondary winding is connected to a standard ammeter usually of 5 amperes capacity. To determine the magnitude of the current in the line it is only necessary to multiply the reading of the ammeter by the ratio of the transformer.

For example, a current transformer with a ratio of 120:1 is used to measure the current in a circuit. The transformer and ammeter are connected as indicated in Fig. 8. Assume the ammeter reading is 4.7 amperes:

Current in the line $= 4.7 \times 120 = 564$ amperes.

Use of Voltmeters with Potential Transformers

Potential transformers are used in the measurement of high voltage to prevent injury to the operator. Connections should be made as indicated in Fig. 4.

To obtain the voltage of the circuit under consideration the same procedure is followed as in the case of the ammeter and current transformer. Suppose the primary of the transformer to be rated 2200 volts and the secondary 110 volts; this indicates the ratio of the transformer to be 20. Assume the voltmeter which is connected to the secondary of the transformer reads 100 volts:

Voltage of the circuit $= 100 \times 20 = 2000$ volts.

Use of Wattmeters with Instrument Transformers

Current transformers may be used to extend the current range of wattmeters or to insulate the wattmeter from the high line voltage.

Potential transformers may also be used to extend the voltage range or to insulate the instrument.

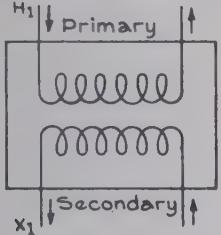
The connections for single-phase measurement are given in Fig. 19. Ammeters and voltmeters may be included in this circuit in accordance with previous diagrams.

Polarity Markings of Instrument Transformers

One primary and one secondary terminal of each instrument transformer are marked H_1 and X_1, respectively, to indicate the relative instantaneous direction of primary and secondary currents. When current is flowing "in" at the marked primary terminal, current is flowing "out" at the marked secondary terminal. See diagram at top of next page.

Either the marked or unmarked terminal of the primary winding of the current transformer can be connected either to the generator or load side of the line; and likewise, either the marked or unmarked terminal of the primary winding of a potential transformer can be connected to either high-voltage line. However, the relative polarity of the primary and secondary windings is important. Connections can be made by assum-

ing that the marked secondary line is a continuation of the marked primary line.



Polarity Markings of Instrument Transformers

COMBINATION VOLTMETER-WATTMETERS FOR APPLIANCE TESTING

Movement

The combination voltmeter-wattmeter is an electrodynamic instrument equipped with receptacles and changeover switch for appliance testing.

External Connections

To check line voltage and power input of an electrical appliance, first disconnect the appliance from the outlet (source) then reconnect through the instrument as shown in Fig. 20. The following sequence in connecting is suggested but is not essential.

1. Connect appliance to instrument "Load" (Lead "A" in Fig. 20).
2. Connect lead "B" first to instrument "Line" receptacle, then to outlet.
3. Snap switch to "Volts" and read values directly on the lower scale. Then snap switch to "Watts" and read values directly on upper scale. The appliance is energized all the time it is connected through the instrument.

TYPE AP-9 POINTER-STOP AMMETER

The term "pointer stop" has been applied to indicating instruments equipped with an adjustable pointer stop in addition to the fixed stop normally employed to prevent overtravel of the pointer. The function of the pointer stop is to reduce the time interval required for the pointer to arrive at its final indication and thus adapt the instrument to the measurement of current values of short duration.

The pointer-stop mechanism consists of a micrometer adjusting screw, threaded through a carrier to which is attached an insulated pin which engages the pointer. The micrometer adjusting screw terminates in the knob on the right-hand side of the instrument. Turning this knob moves the stop and pointer up or down scale as required, the direction of travel being indicated by the target at the back of the scale opening.

To measure a current, place the instrument in a position for convenient reading, and at as liberal a distance as practicable from conductors carrying high current, such as welding electrodes, to eliminate stray field errors. A distance of one foot per 2000 amperes of secondary current is ample if the instrument is placed so the observer faces the electrodes when reading the instrument.

In welding work, this instrument is commonly used with a split-core current transformer which

is attached to either lead of the welder transformer primary, and the instrument is thus calibrated in terms of primary current. A knowledge of the welder transformer ratio is thus necessary to obtain results in terms of secondary (or welding) current.

After connecting the instrument, set the controls in the desired position and energize the welder. Observe the pointer reading, repeat the operation, and move the pointer stop up scale until the pointer oscillation is just noticeable, say $\frac{1}{64}$ in., as current is applied. Record this reading, add or subtract the value indicated on the curve, Fig. 1, for the percentage of full scale value observed, and the result is the primary current as referred to the instrument transformer and welder transformer. To obtain welder secondary current, multiply this value by the welder transformer ratio.

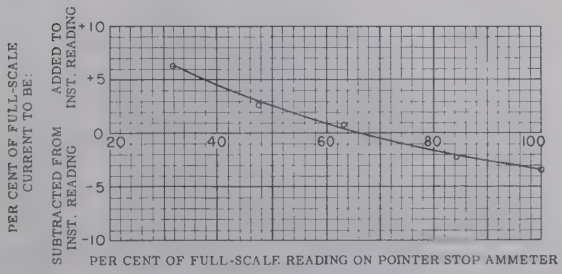


Fig. 1. Response Curve of Type AP-9 Pointer-stop Ammeter for Full Wave Impulses from 3 to 10 Cycles on 60-cycle Circuit

TYPE DP-9 INSTRUMENTS

Type DP-9 instruments have either a core-magnet element or a concentric-magnet element, depending on range and sensitivity. All Type DP-9 instruments are self-shielded from external magnetic fields. Type DP-9 instruments are supplied as ammeters, voltmeters, milliammeters, microammeters, thermal voltmeters, and millivoltmeters.

Polarity

The polarity marking is the same for all direct-current DP-9 instruments. One binding post, the common, is marked "+"; the others are marked with the normal ratings for their respective ranges. One cable of the leads which are furnished with millivoltmeters has a red tracer which permits identification of polarity.

Connections

When using a multiple-range instrument to measure an unknown voltage, the highest range should be tried first. If the indication is too low on the scale to be read to the desired accuracy, a lower scale may then be used.

If one side of the line is grounded the instrument, if an ammeter, should be connected to that side wherever practicable. When working on circuits that are hazardous, it is desirable to ground the instrument if conditions will allow it.

This should be done to protect the operator and the instrument.

DP-9 voltmeters are high-resistance instruments and should be connected across the line as shown in Fig. 22.

Extension of Range

The ranges of DP-9 voltmeters and millivoltmeters may be extended by the use of multipliers (external resistors). When these are not Type YR multipliers built especially for use with these instruments, care should be taken to see that they have a sufficient current rating, are well insulated, and wound of wire having a negligible resistance temperature coefficient.

Standard Type YR multipliers are nearly always built to the lowest range of the instrument with which they are used. There are two principal reasons for this: one is to keep the potential across the instrument at a minimum, and the other is to keep all unnecessary heat out of the instrument.

The connections to be followed when using a multiplier with a DP-9 instrument are shown in Fig. 21.

Type YR multipliers are stamped with their resistance and each post other than the common or "0" post is stamped with a constant by which the scale reading should be multiplied to obtain the true voltage. When using other than standard

multipliers, this constant (K) may be determined in the following manner:

$$K = \frac{\text{Resis. of Instrument} + \text{Resis. of Multiplier}}{\text{Resistance of Instrument}}$$

The resistance of the instrument is given on the scale plate.

Lead Resistance

The resistance per volt of DP-9 voltmeters is so high that ordinary lead resistance has no readable effect. For example, using a standard 150-v DP-9, the lead resistance would have to exceed 30 ohms before the effect could be read on the scale. Standard 5-ft ammeter shunt leads have a resistance of about 0.03 ohm which is allowed for in the instrument calibration. While these standard leads are interchangeable, the substitution of any other leads should be made only when the lead resistance is known and the correction applied to instrument readings if necessary.

DP-9 Millivoltmeters

Millivoltmeters are made in several standard ranges and are principally used in conjunction with various types of shunts for measuring direct current. Those intended for use with Form 16 or Form 18 (portable) shunts have a 50-millivolt range and a resistance of approximately 5 ohms.

Where an instrument is to be used with a particular shunt, the scale may be marked

directly in amperes. Where it may be used with a number of shunts of different rating, the general practice is to mark two scales on the scale plate, one of 100 divisions and one of 150 divisions. These are marked 0–100 and 0–150. This permits the use of the shunts of the more usual ratings with simple numbers for scale constants. Thus with a shunt of 1, 10, or 100 amperes rating, the 100-division scale will be used as the indications of the millivoltmeter multiplied by 0.01, 0.1, or 1.0 will give amperes directly. A shunt of 1.5, 15, or 150 amperes rating would be used with the 150-division scale as there the constants would also be decimal values. A 5-ampere or 50-ampere shunt would

Shunt Rating Amperes	Scale Constants	
	100-division Scale	150-division Scale
1	0.01	
3		0.02
5	0.05	
10	0.1	
15		0.1
20	0.2	
30		0.2
50	0.5	
75		0.5
100	1.0	
150		1.0

be used with the 100-division scale, and the multiplying constant would be 0.05 and 0.5, respectively. A 75-ampere shunt would be used with the 150-division scale as the multiplying constant there would be 0.5. The tabulation shows scale constants for various standard shunts.

When using a millivoltmeter with a shunt, if the instrument should read backwards, reversing the leads will cause it to read up scale. When the DP-9 millivoltmeter is used to measure amperes with a shunt, it should be connected as shown in Fig. 23.

DP-9 Ammeters (Self-contained)

The movement of the self-contained ammeter is the same as that used in millivoltmeters.

The instrument should be connected in the circuit as shown in Fig. 24.

REPAIR AND CALIBRATION

If the instrument needs repair, or a check of its calibration is desired, obtain shipping instructions from the nearest General Electric apparatus sales office. Pack the instrument carefully in a nest of shredded newspaper or excelsior, and send it to the instrument service facility specified by the apparatus sales office.

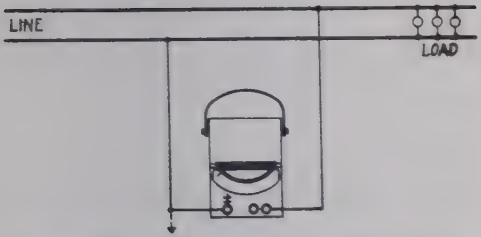


Fig. 2. Type AP-9 Voltmeter Connected Across Line

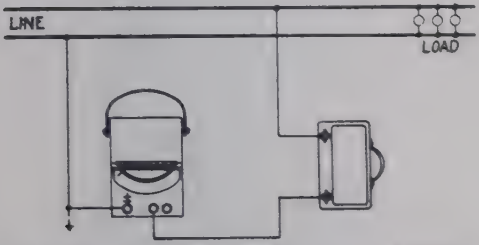


Fig. 3. Connections for Type AP-9 Voltmeter and Multiplier

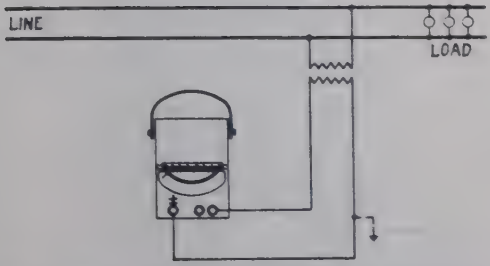


Fig. 4. Type AP-9 Voltmeter Used with Potential Transformer

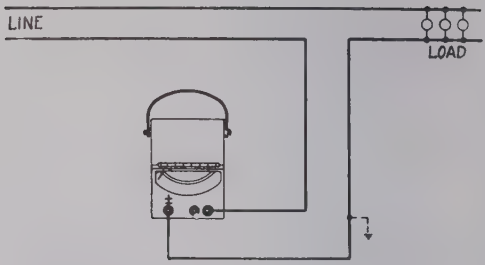


Fig. 5. Type AP-9 Ammeter Connected in Power Circuit

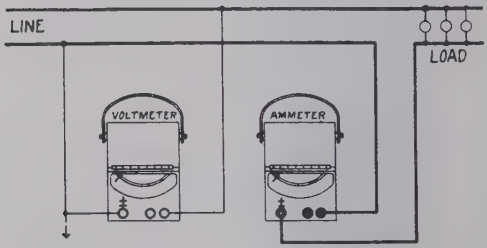


Fig. 6. Voltmeter and Ammeter in Power Circuit, Type AP-9

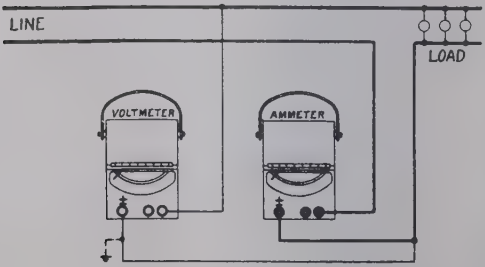


Fig. 7. Voltmeter and Ammeter in Power Circuit, Type AP-9

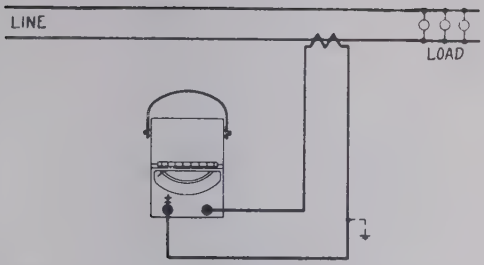


Fig. 8. Type AP-9 Ammeter with Current Transformer

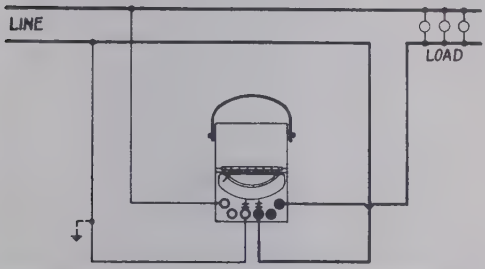


Fig. 9. Type AP-9 Wattmeter in Single-phase Circuit

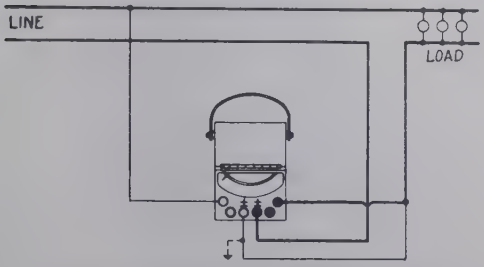


Fig. 10. Type AP-9 Wattmeter in Single-phase Circuit

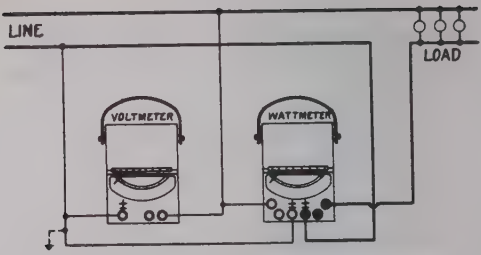


Fig. 11. Voltmeter and Wattmeter in Power Circuit, Type AP-9

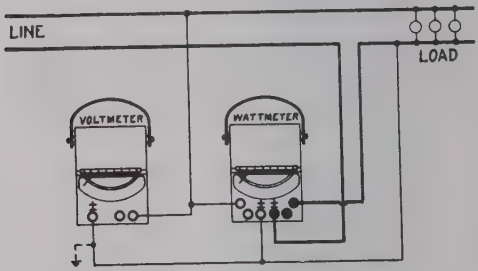


Fig. 12. Voltmeter and Wattmeter in Power Circuit, Type AP-9

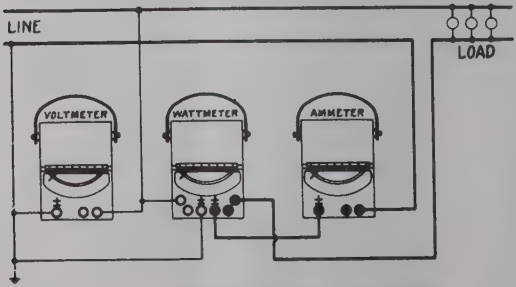


Fig. 13. Voltmeter, Wattmeter, and Ammeter in Power Circuit, Type AP-9

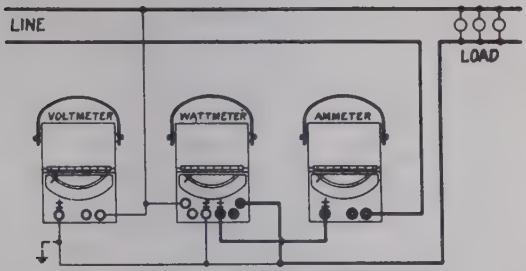


Fig. 14. Voltmeter, Wattmeter, and Ammeter in Power Circuit, Type AP-9

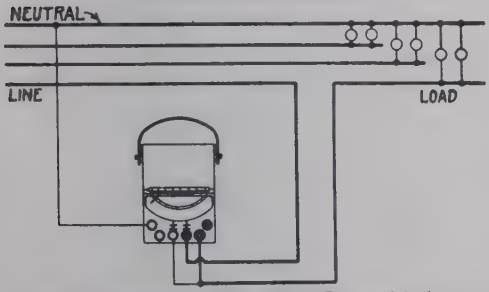


Fig. 15. Single-phase Wattmeter in Balanced 3-phase 4-wire Circuit, Type AP-9

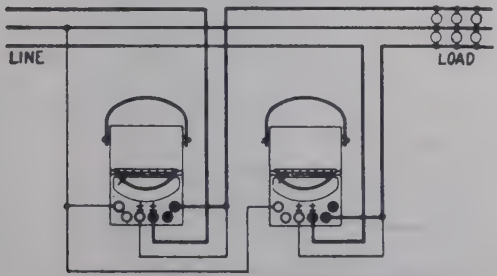


Fig. 16. Two Wattmeters Connected for 3-phase Balanced or Unbalanced Voltages or Load, Type AP-9

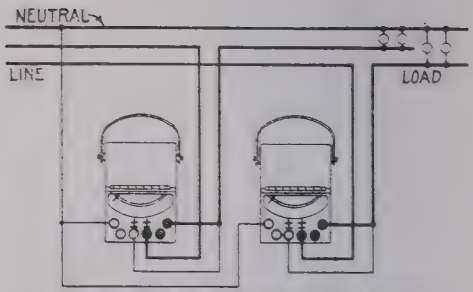


Fig. 17. Two Wattmeters for 2-phase 3-wire Balanced or Unbalanced Load, Type AP-9

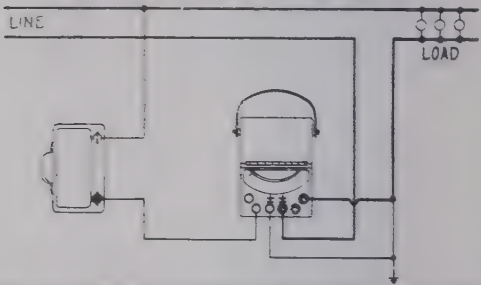


Fig. 18. Multiplier and Wattmeter Connections, Type AP-9

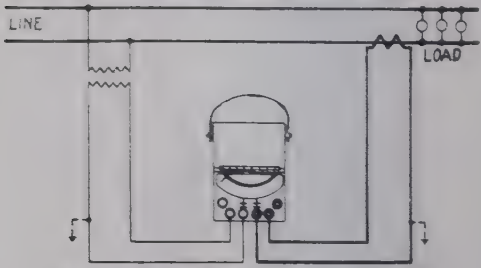


Fig. 19. Type AP-9 Wattmeter with Current and Potential Transformers

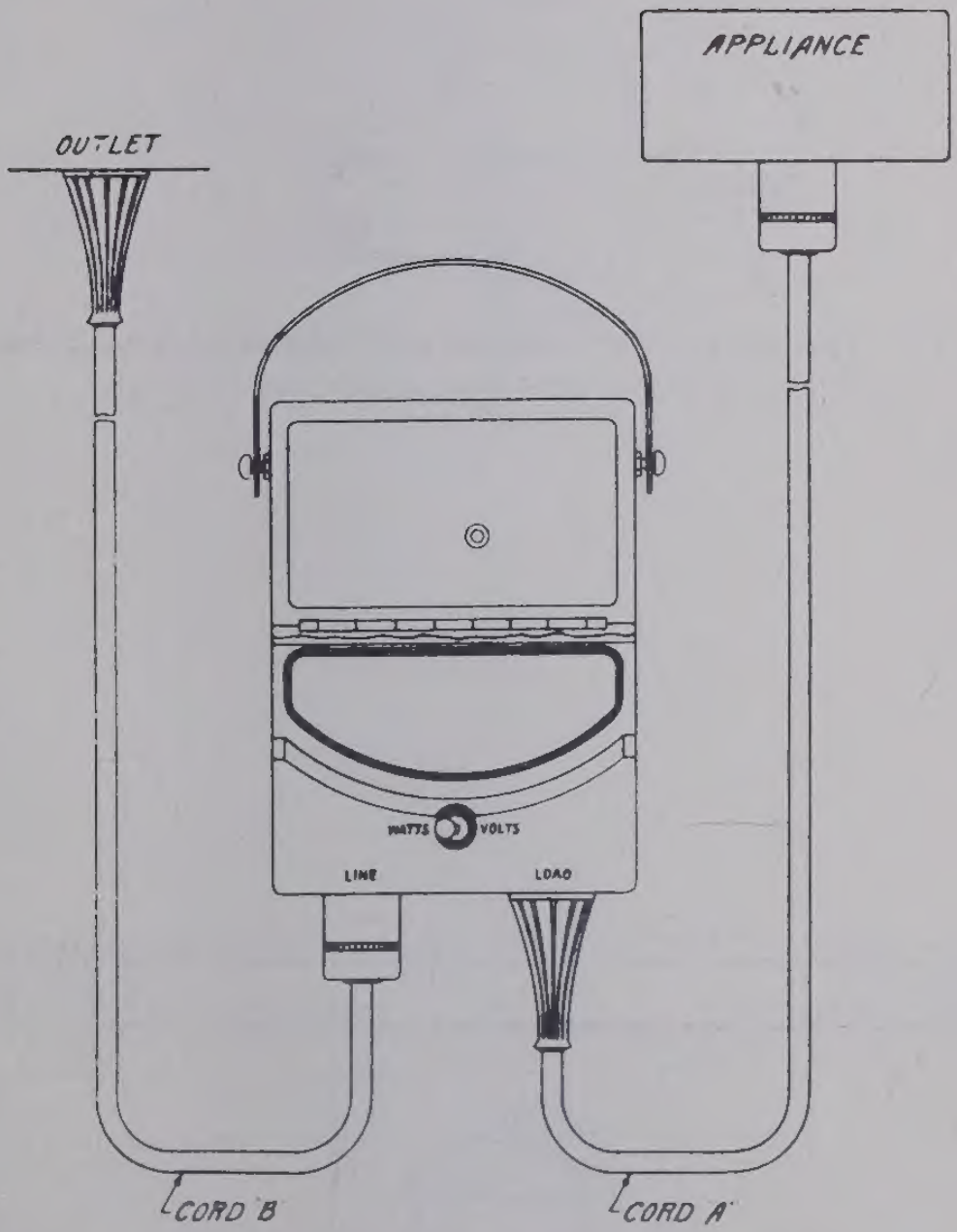


Fig. 20. External Connections of Type AP-9 Volt-wattmeter

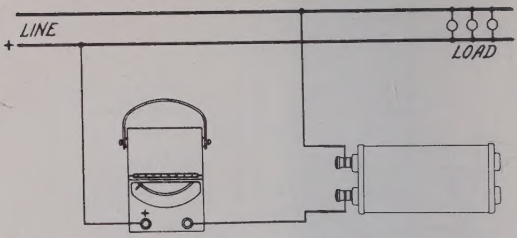


Fig. 21. Connections for Voltmeter and Multiplier, Type DP-9

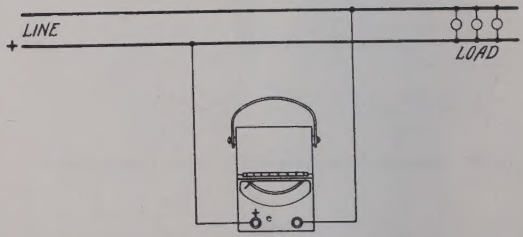


Fig. 22. Type DP-9 Voltmeter Connected Across Line

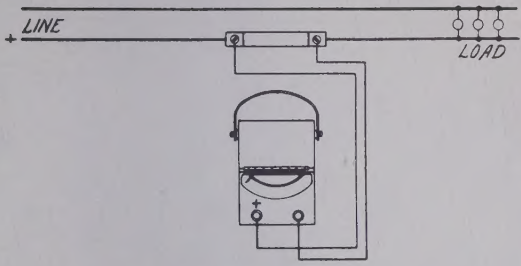


Fig. 23. Type DP-9 Ammeter with External Shunt

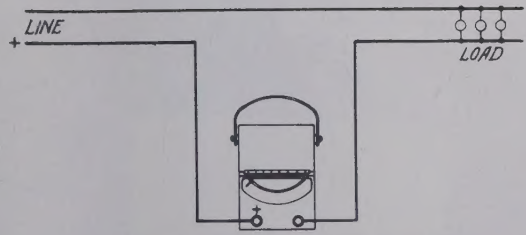


Fig. 24. Type DP-9 Ammeter, Self-contained

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